BUILDING A CO_2 STORAGE HUB IN THE CENTRAL NORTH SEA

SCO$_2$TLAND'S BLUEPRINT FOR A CARBON-PROOFED ECONOMY

Picture courtesy of Shell UK

"In geological terms the Central North Sea is as near to perfect as you will find anywhere in the world when it comes to offshore sub-surface storage of CO_2"

Stuart Haszeldine OBE - Professor of Geology and Carbon Storage at The University of Edinburgh

 Shell's current development at Peterhead is designed to capture all the CO_2 from SSE's gas-fired power plant

Shell and SSE are planning the world's first full-scale gas carbon capture and storage project in Scotland

The International Energy Agency has long argued that Carbon Capture and Storage is the single most important technology we have in the battle to reduce CO_2 emissions from power and industrial sources. Without it we will simply fail in our bid to meet the energy challenge; ensuring carbon emissions are reduced, supplies stay secure and costs are kept down. It's a challenge that we must take on rather than pass to future generations when the need will be greater and cost more to overcome.

Now, as economies begin to recover and global reliance on low-cost energy from coal and gas shows no sign of diminishing, the time has come to renew our efforts and drive this essential technology through to completion at industrial scale.

Scottish Enterprise has undertaken work which:

- Reviews the investment case for CCS
- Reframes the wider economic arguments, ensuring the long term commercial viability
- Reinforces Scotland's competitive advantage by putting the Central North Sea at the heart of the Europe-wide development programme

Put simply, we have to develop CCS and we need to start now. This short report, incorporating new economic modelling by Element Energy on behalf of Scottish Enterprise, shows how the UK is leading Europe when it comes to funding the development of CCS. And why Scotland, with it's unique proximity to significant offshore storage sites in the Central North Sea, an almost ready-made infrastructure and 40 years of oil and gas production experience makes it the perfect place to start.

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Some context

Capturing carbon from fossil fuel power stations or other industrial sources of CO_2 emissions such as steel and cement works and then transporting the gas to very deep subsurface rock formations, for safe and permanent storage in the microscopic pores that once held oil and gas, isn't new. There are already systems operating effectively in Canada, the US and Australia.

Europe, once at the forefront of this innovative technology that can give us clean energy from abundant fossil fuels like coal, is now lagging behind. Hit hard by the financial crisis at the end of the last decade CCS development fell off national political agendas as economies faltered. In its wake, corporate appetite for investment came to a virtual standstill.

Here in the UK though, CCS development may have slowed since 2008, but it certainly hasn't been 'parked' like it has in some European countries. The UK and Scottish Governments are one of the few administrations anywhere in the world to make it a legal requirement to reduce CO_2 emissions by 80% in 2050 compared to the emission levels of 1990.

Wind and other renewables certainly have a role to play in meeting those targets, but we also need to ensure supplies of energy are secure, reliable and affordable. This challenge – CO_2 reduction, security of supply and lower costs – is known as the energy trilemma.

The UK has recognised that to meet climate change targets at the lowest cost, CCS will have a critical role to play when it comes to decarbonising both power and industrial emitters. First of a kind projects are inevitably likely to cost more - as with any new technology, but with experience and advances in technology, costs come down over time.

For this reason, the Department for Energy and Climate Change's CCS Commercialisation Programme is funding two projects for what's known as a Front End Engineering Design (FEED) study. As with any major engineering project, FEED studies are carried out to define what will be built, how it will operate and what it will cost. The first CCS FEED study is being carried out by Shell and SSE at a gas-fired power station at Peterhead on the East coast of Scotland. The second is at the Drax coal-fired power station near Selby in North Yorkshire, England. Both projects are expected to reach a Final Investment Decision in 2015. There are three further CCS projects proposed. One is at Grangemouth in Scotland, one is in the Don Valley in Yorkshire and one is on Teesside in North East England which is aimed at reducing emissions from industrial emitters such as a chemical plant and a steel works.

Humber cluster

Scope for CO_2 commercial growth

Why Scotland?

Scotland has long been at the forefront of global CCS development. ScottishPower, along with National Grid and Shell carried out the first FEED study on CCS in the UK in 2010. Known as the Longannet project it was designed to retrofit the first fully commercial CCS technology to a 2400MW coal-fired power station on the Forth estuary and transport the captured CO_2 along an underground pipeline out into the Central North Sea and store it in a depleted gas field called Goldeneye. This same field is now being proposed as the storage option for the CO_2 that's emitted from SSE's Gas plant at Peterhead. The Captain Clean Energy Project plans to build a new 570MW plant at Grangemouth west of Edinburgh will also use the same pipeline that was identified for use on the Longannet project. Known as Feeder 10, that pipe was originally built to bring gas in from the abundant fields the North Sea. Today now that gas reserves are in decline, the same pipeline can be put to good use transporting CO_2 in the opposite direction. This reduces infrastructure costs. Over 70% of Scotland's CO_2 emitters lie within 10-20km of this pipeline, and can be linked in at low cost to simply decarbonise valuable industries.

Carbon Capture and Storage enjoys significant political support. Stakeholders across the financial, regulatory and environmental spectrum have shown a determination to 'do what it takes to make CCS happen in Scotland'. Communities and key opinion formers too, have long been part of the discussion. They recognise the economic as well as the environmental advantages that come with CCS.

A Scottish workforce has the experience to overcome offshore technical challenges. Since the first North Sea oil came ashore at Cruden Bay on Scotland's East Coast in 1975, Scottish engineers have developed world class offshore skills and an efficient supply chain built around transporting gas and other hydrocarbons safely, and economically. Go to almost any gas or oil field anywhere in the world, and you'll be likely to find Scottish expertise.

Picture courtesy of Chris James

But, it's not just the history, the people and the will that puts Scotland at the centre of a European CCS hub.

East CO_2ast value add

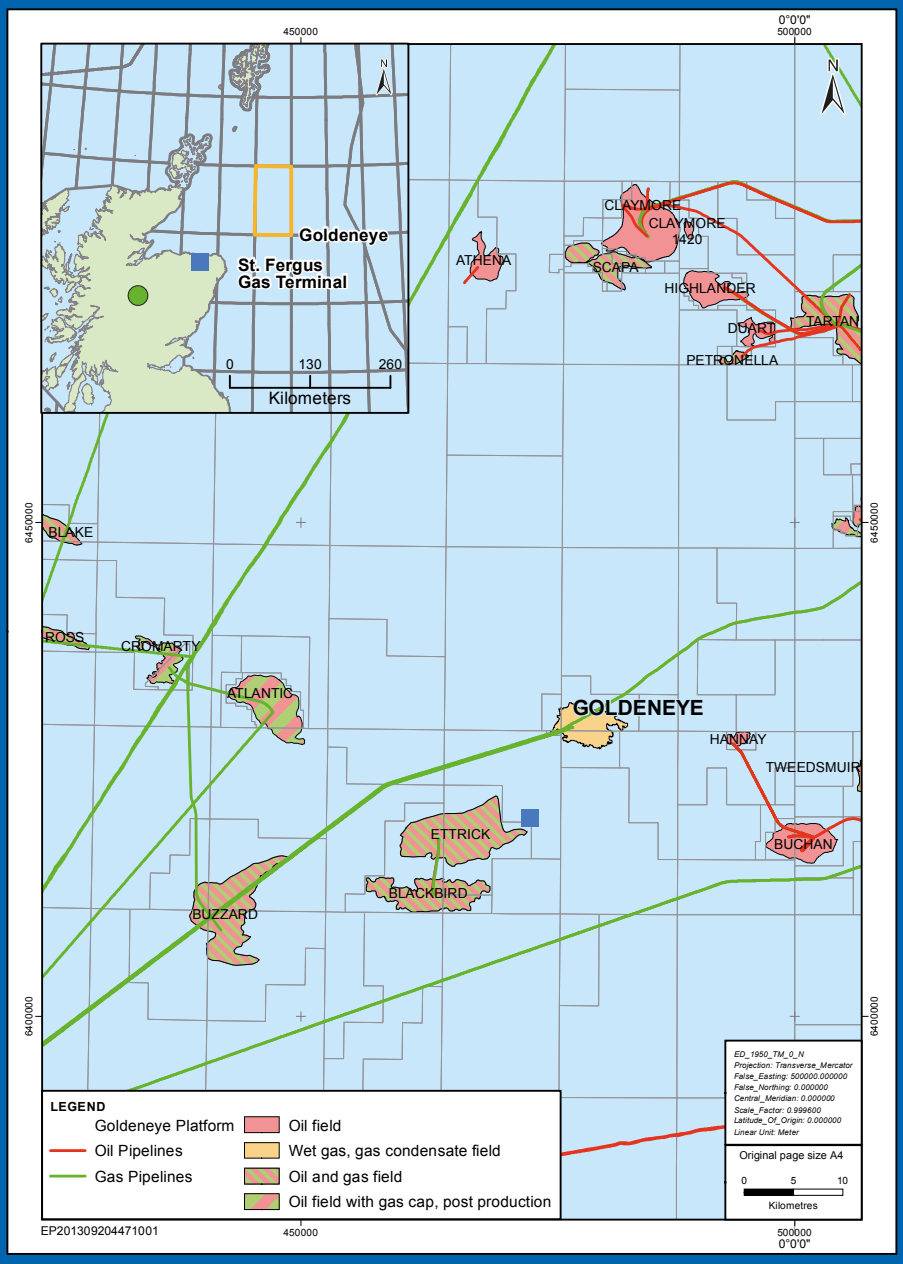
CO_2 storage sites need three essential attributes. They must be:

Affordable

The ready-made transportation infrastructure will give major emitters, from Scotland and beyond, access to the huge storage resource 100 miles off the country's east coast. Capturing CO_2 from multiple sources and then consolidating it in to just one regional network of shared storage sites within the Central North Sea will also drive down costs. And as a site in one part of the region reaches capacity it must be cost-effective for operators to move to a site in another part of the region without the need for extensive new infrastructure. There is more than 5,000 km of pipeline already installed on the sea bed of this resource rich region.

Deliverable

With decades of detailed analysis by oil and gas operators in the Central North Sea, perhaps more is known about the sub-surface geology in this part of the world than anywhere else. And one of the best understood sites in the whole of the UK Continental Shelf is the Goldeneye gas condensate field in the Outer Moray Firth. The long term detailed modelling engineers and geologists constructed as they extracted gas from the site offers Shell the confidence to develop CCS in the Central North Sea rather than at any other global site.

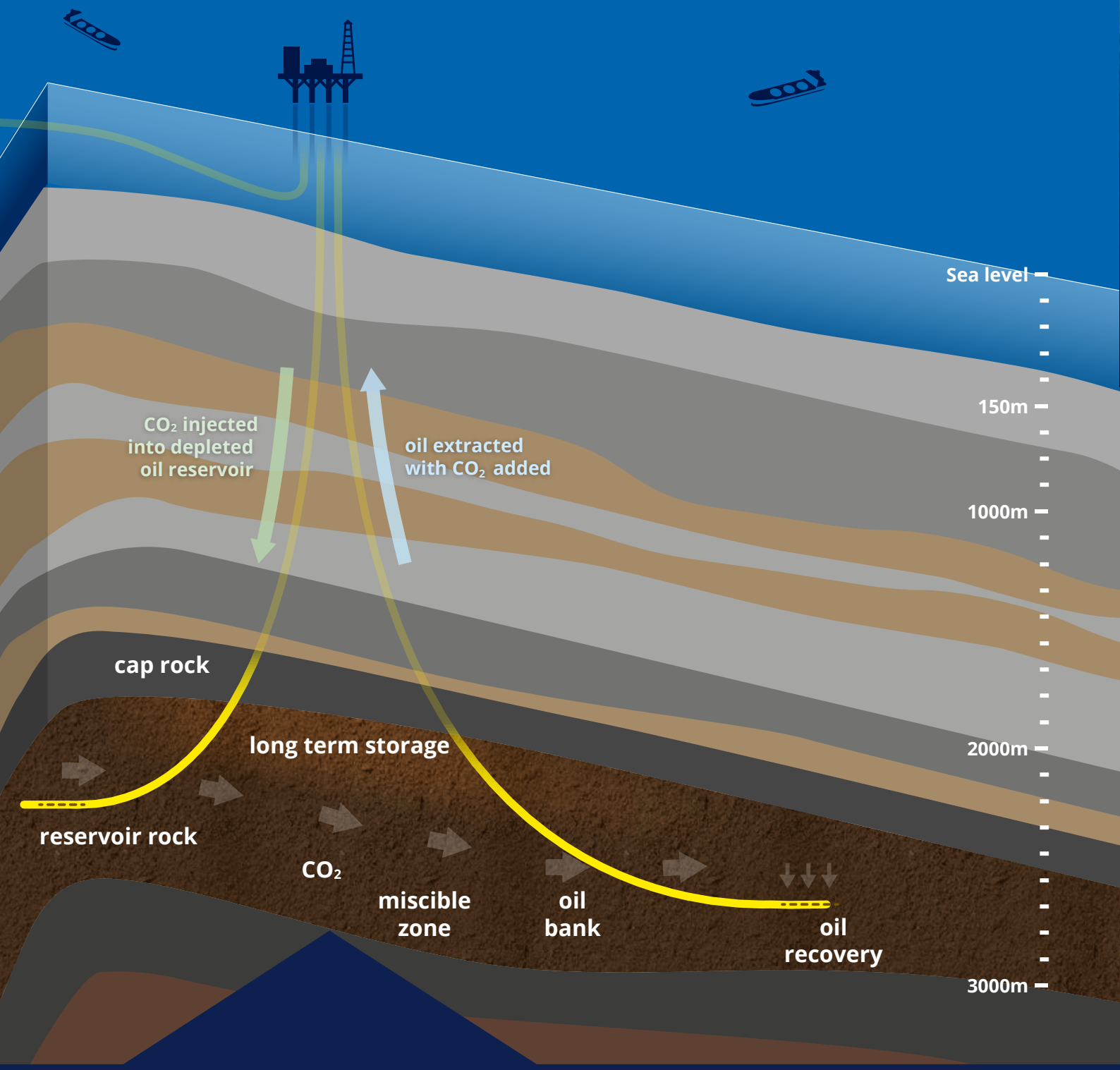


Diverse

As CO_2 capture and transportation develops, the site in which the gas will be stored must be large enough to accommodate growing demand. The Captain sandstone formation, of which the Goldeneye field is part, is large enough to hold all the CO_2 from the UK's gas fuelled power plants for the next 100 years.

The C_2oncept

With cost reduction being one of the key challenges to developing full-scale CCS, the prospect of injecting CO_2 into existing oil fields to help extract more of the fossil fuels we are reliant upon is seen by many as a win-win. Not only does it remove large quantities of the greenhouse gas for good, but it extends the life of the field significantly – in some cases by up to a third. Develop that logic slightly further and it's easy to envisage a scenario where CO_2 – far from being a by-product of power stations and heavy industry – one that requires subsidy payments and regulation to achieve reductions, could, one day, become a valuable commodity which can be sold to oil and gas producers. What was once a waste gas becomes an asset if it's used for Enhanced Oil recovery. It's known as CCS with EOR in some quarters, but put simply it's CCS^{+}.



Statoil has been operating a CCS system at its Sliepner field in the North Sea since 1996.

Picture courtesy of Statoil

CCS+

It is a process that has been used safely, economically and effectively, at Rangely field in Colorado since 1972, and is linked to CCS at Weyburn-Midale in Canada in 2014.

CO_2 is injected into oil wells under high pressure and low temperature. The CO_2 has three effects on the underground oil that lead to an increase in recovering the resource:

- The CO_2 acts as a solvent, cleaning oil trapped in the microscopic pores of the reservoir rock.
- The CO_2 also acts as a pressurising agent pushing more oil out of the rock.
- The CO_2 reduces the oil's viscosity helping it flow.

To carry out CCS with CO_2-EOR at industrial scale we must:

- Understand the site, ensuring that it ticks the Affordable, Deliverable and Diverse boxes.
- Be certain we can transport a reliable and consistent stream of pure CO_2 to the site
- Plan the infrastructure designed to deliver the gas for the long term

Scottish Enterprise is at the forefront of this work because it recognises that by adding EOR to CCS you get CCS+

Transforming the economics of the technology.

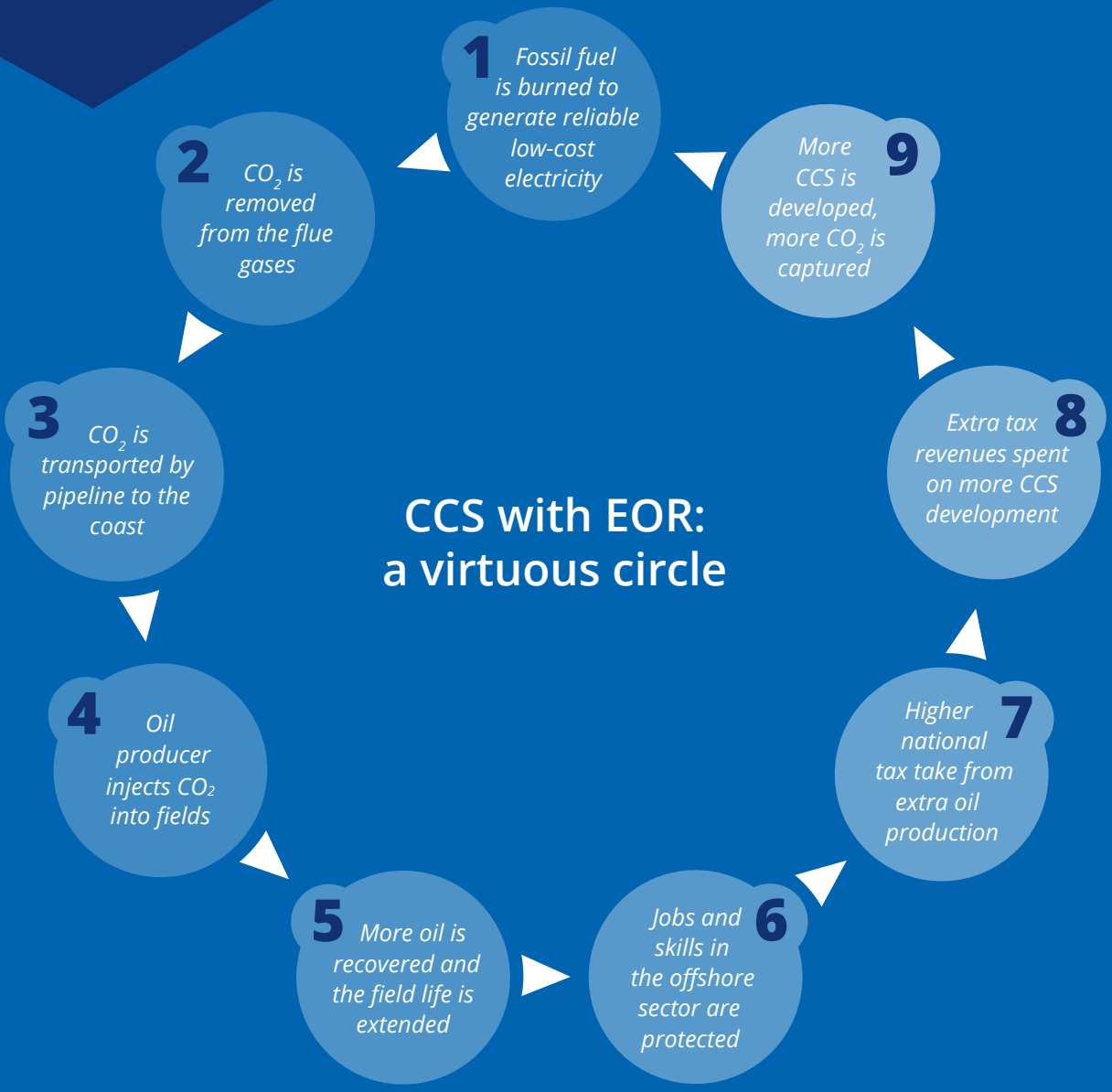
There's only one place in Europe which ticks all these boxes. But take a closer look and the case for investment becomes truly compelling.

CO_2ntinuous growth

The greatest challenge for CCS developers has always centred on the investment case. By developing CCS with EOR, emitters will be attracted to regions which offer the lowest cost solutions when it comes to meeting emissions performance standards.

The answer can perhaps be found in North America. There CO_2 isn't seen as a problem, but an asset that can be put to good use. Today, in the oil fields of the West Texas Permian basin or at Weyburn in Saskatchewan, Canada, CCS with EOR is transforming the economics of fossil fuel extraction. EOR is rapidly becoming the driver of CCS projects around the world.

It creates a virtuous cycle.



The value of the additional oil recovered through CO_2-EOR (ca 1.5bn barrels) broadly matches the cost of implementing and maintaining a CCS network in the Central North Sea

The challenge though, is how to get the virtuous circle in place.

The economic arguments

Energy economists argue there are three ways to develop CCS:

1. Let the markets decide.
2. Pay for storage from general taxation and incentivise emitters to capture CO_2.
3. Provide up front support to create the virtuous cycle and recoup costs from direct taxation of the sector during operations.

EOR is the catalyst for increasing the oil recovered from the Central North Sea and extending the life of this valuable resource. It transforms the economics of CCS and the additional tax receipts support further rollout of the technology. It's another virtuous cycle.

The case for Scotland is strengthened yet further when the supply chain skills base is examined. Investment in a CCS network can be split in to four components:

1. CO_2 purification, drying and compression. This requires complex chemical processes and advanced engineering. Developers will look to manufacturers with proven credentials and solid experience that have been developed in the country's hydrocarbon sector.
2. Pipeline transport. Ensuring structural integrity and longevity means precision engineering. Again, best practice is found in the offshore oil and gas industry.
3. Storage. Understanding the sub-surface geology and interpreting the seismic data requires some of the best brains (and computing power) in the business. Scottish based companies and research groups are amongst the best in the world.
4. Scotland's oil and gas supply chain has always been good at innovation. EOR is just the next phase.

A fully fledged CCS network using the Central North Sea hub could be worth up to £7bn to the Scottish economy by 2047. It would create up to 2000 new jobs in the process. That's on top of the safeguarded jobs in the Central North Sea's oil and gas sector.

If oil is more than $100 a barrel, the extra tax revenue from oil which would stay in the ground is worth much, much more than that - at least £90bn, according to Scottish Carbon Capture and Storage.

And, best of all, Scotland can invest in a fully functioning CO_2 pipe transport network, offering the chance to store European CO_2.

Connecting the dots for future growth

2013-2017

A rational outline of a Central North Sea CO_2 storage hub sees the Feeder 10 pipeline transporting CO_2 from a new power plant at Grangemouth up to a CO_2 hub at Peterhead where it joins CO_2 from the Peterhead gas plant. The CO_2 is pumped to the depleted gas condensate field, Goldeneye 90 miles offshore. Early analysis should begin on EOR opportunities in the Buzzard Field. A second Central North Sea storage hub would be developed at the Auk hub storing emissions from Teesside and the Humber region. Investment in the project will be worth £762m to the Scottish economy

2018-2022

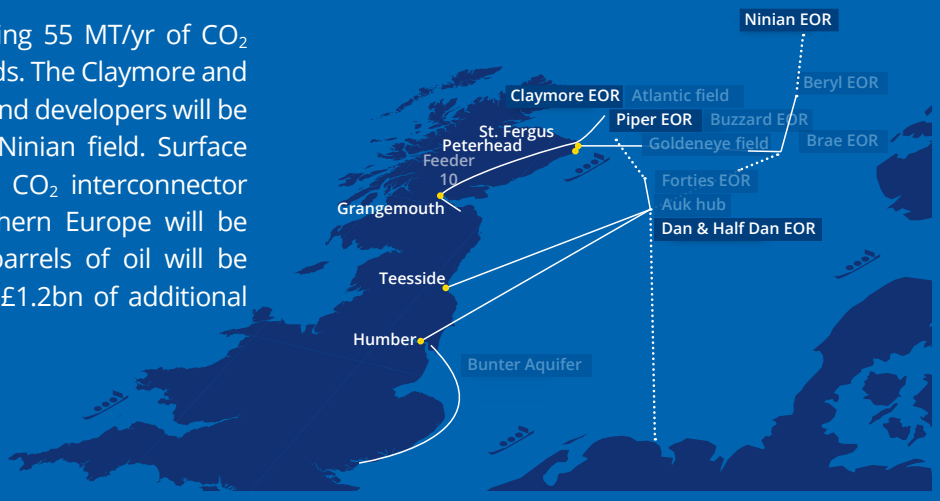
As CO_2 supplies from two or three emitters become more certain and reliable, North Sea operators can use the gas to extend the life of reserves in both the Buzzard and Forties fields - safeguarding jobs and reducing overall investment costs. In this period a further £530m will be added to the Scottish economy and more than 15m tonnes a year will have been abated from the UK's CO_2 emissions.

2023-2027

As demand for CO_2 increases and more sub-sea trunk lines become available, greater EOR opportunities open up. By now, operators will want consistent and certain supply of CO_2 and we can expect to see the emergence of a CO_2 shipping market, with surface vessels transporting the gas from North Sea basin countries such as Norway and Germany. This receiving port could be built at Peterhead or at Hound Point on the Forth estuary. Over this period more than £1bn worth of additional value will be added to the Scottish economy and nearly 10m additional barrels of oil will be extracted from the Central North Sea

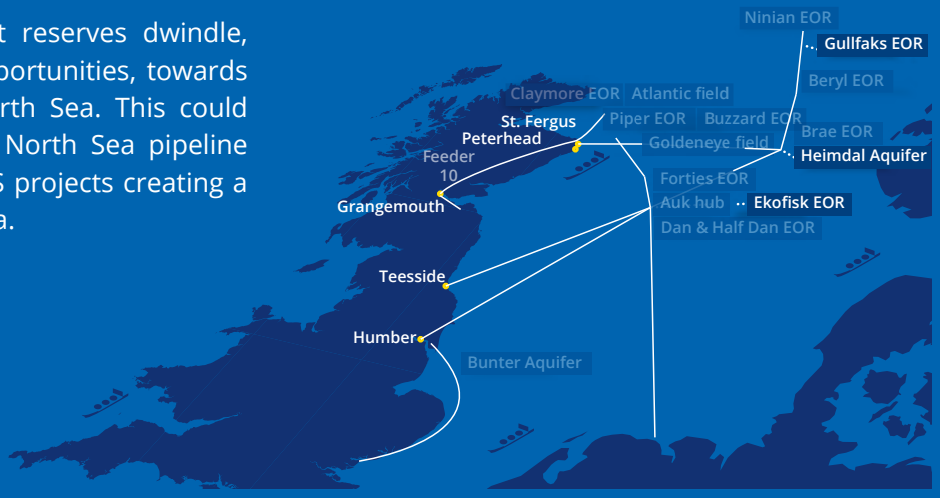
2028-2032

By the end of the 2020s we could be seeing 55 MT/yr of CO_2 flowing towards the Buzzard and Forties fields. The Claymore and Piper fields too will be benefiting from EOR and developers will be looking to extend CO_2 storage out to the Ninian field. Surface shipping of CO_2 will commence and a CO_2 interconnector between the Central North Sea and Northern Europe will be under consideration. An additional 25m barrels of oil will be extracted from the Central North Sea and £1.2bn of additional value will be added to the Scottish economy.



2033-2037

As global demand for oil increases, but reserves dwindle, developers will seek to 'step-out' EOR opportunities, towards the Norwegian sector of the Central North Sea. This could include fields at Gullfaks and Ekofisk. A North Sea pipeline infrastructure would link to European CCS projects creating a CO_2 superhighway to the Central North Sea.



2038-2042

By the middle of the century, using this scenario, we will see a fully integrated North Sea CO_2 transport and storage infrastructure servicing the UK and Europe's storage needs for decades to come. There will be an extra 5,000 km of pipeline servicing the CO_2 distribution – that's on top of the 10,000 km of pipeline that already exists on the UK Continental Shelf. More than 1.5bn additional barrels of oil could be extracted; generating additional tax revenues, safeguarding jobs and energy supplies and storing much of Europe's CO_2 safely and permanently.

Living in a carbon constrained world.

It is, of course, tempting to say that none of this matters now. That we'll find a new source of low-carbon energy before climate change has any real impact. Or that our national carbon footprint is tiny compared to that of the fast developing nations like China and India. We could decide not to act at all and leave the problem to our children and their children. But think of it another way. History tells us that the countries that develop fastest are always the countries that innovate first, embrace change and invest for their future.

When it comes to growth, we can see a world, not too far off, where the countries that have a competitive advantage won't be the ones that offer a low wage economy, but the countries that can offer a low-carbon economy. Countries whose industrial base isn't taxed into defeat because they have to meet global carbon emissions taxes. You think this is a long way off? These days are already here. The next time you take a flight, or fill your car with fuel, or pay your electricity bill – take a close look at the carbon levy.

The winners in a carbon constrained world will be the countries that are first to be ready for it. CCS in Scotland, storage and CO_2-EOR in the Central North Sea, offers us, we think, an opportunity that's too good to miss and too important to ignore.

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Picture courtesy of Chris James

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